Iranian Journal of Engineering Geology
Winter 2019, Vol.11, No.4

Predicting the brittleness of granitic rocks in Tavandasht and Gosheh (Borujerd) by Schmidt hardness and petrographic characteristics

R. Khorasani[1], R. Ajalloeian[2], A. Jamshidi[3] *

Abstract

Brittleness is one of the most important mechanical properties of rock that is widely used in geotechnical designs such as drilling operations and underground structures. So far, standard method for estimating the brittleness of rocks has not been introduced and therefore, indirect methods are used to estimate them. In this research, brittleness of granitic rocks are estimated from Schmidt hardness and petrographic characteristics (minerals mean size and mineralogical composition) using simple and multivariate statistical relationships. To achieve these goals, 10 different granite rocks were collected from quarries Tavandasht and Gosheh around Borujerd (Lorestan province). Based on laboratory tests, brittleness index, Schmidt hammer hardness, minerals mean size and quartz to feldspar ratio were determined. Then, different models were fitted to the data for estimating the brittleness. The results of simple statistical relationships indicate that there are moderate correlations (determination coefficients ranging from 0.70 to 0.87) between the brittleness index with Schmidt hammer hardness, minerals mean size and quartz to feldspar ratio. While the multivariate statistical relationships indicate a significant effect of the minerals mean size and quartz to feldspar ratio on the accuracy of correlation between the brittleness index with Schmidt hammer hardness s (with determination coefficients of 0.91 and 0.93, respectively).
permeability has increased and the unconfined compressive strength and the CBR has decreased as the artificial rain become more acidic or alkaline, and precipitation years increased from one-year to twenty-years.

Keywords: Brittleness, Schmidt hardness, Minerals mean size, Quartz to feldspar ratio, Granite

[1] M.Sc, Department of Geology Eng, University of Isfahan, Isfahan, Iran
[2] Professor, Department of Geology Eng, University of Isfahan, Isfahan, Iran
[3] Assistant Prof, Department of Geology, Lorestan University, Khoramabad, Iran
*** Corresponding Author:** Jamshidi.am@lu.ac.ir

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Extended Abstract:

1. Introduction

Brittleness is one of the most important mechanical properties of rock that is widely used in geotechnical designs such as drilling operations and underground structures. So far, standard method for estimating the brittleness of rocks has not been introduced and therefore, indirect methods are used to estimate them. Nonetheless, most researchers find brittleness as a function of uniaxial compressive strength and Brazilian tensile strength of rocks. Therefore, to evaluate the brittleness of the rocks, some of researchers use uniaxial compressive strength and Brazilian tensile strength. Since uniaxial compressive strength and Brazilian tensile strength tests are time-consuming and require standardized core cores, a number of researchers have used physical characteristics such as porosity, density, and absorption and mechanical characteristics such as ultrasonic waves, Schmidt hardness and point load index for initial evaluation of brittleness (Yagiz 2006, Tiryaki 2006, Yilmaz et al., 2010, Altindag and Guney 2010, Yarali and Soyer 2011, Heidari et al., 2014).

In this research, brittleness of granitic rocks are estimated from Schmidt hardness and petrographic characteristics (minerals mean size and mineralogical composition) using simple and multivariate statistical relationships.

2. Materials and methods

To achieve these goals, 10 different granite rocks were collected from quarries Tavandasht and Gosheh around Borujerd (Lorestan province). Based on laboratory tests, brittleness index (B), Schmidt hammer hardness (SH), minerals mean size (MGS) and quartz to feldspar ratio (Qz/Fl) were determined. Then, different models were fitted to the data for estimating the brittleness.

3. Results and Discussion

3.1. The correlation between B with SH, MGS and Qz/Fl

One of the most common accepted methods of investigating empirical relationships between rock properties is regression analyses. The authors this work attempted to develop the best correlations between B with SH, MGS and Qz/Fl of samples to attain the most reliable empirical relations. Linear ($y = ax + b$), power ($y = ax^b$), exponential ($y = ae^x$) and logarithmic ($y = a + \ln x$) curve fitting approximations were executed and the best approximation correlation was determined.

It can be seen from Eqs. (1) to (3) that moderate correlations between B with SH, MGS and Qz/Fl were found with R^2 of 0.70, 0.73 and 0.86, respectively. The Eqs. of these correlations are as below:

$$\mathbf{B} = 0.8006\,\mathbf{SH} - 22.508 \qquad R^2=0.70 \tag{1}$$

$$\mathbf{B} = 26.53\,\mathbf{MGS}^{-0.589} \qquad R^2=0.73 \tag{2}$$

$$\mathbf{B} = 6.4475\,\mathbf{(Qz/Fl)} + 11.938 \qquad R^2=0.86 \tag{3}$$

3.2. The effect of MGS and Qz/Fl on the correlation between B and SH

Multivariate regression is one of the most commonly accepted methods of data analysis that may be appropriate whenever a quantitative variable (dependent variable) is to be examined in relationship to any other parameters (independent variables). In this study, the multivariate regression analysis was used to investigate the effect of MGS and Qz/Fl on the correlation between B and SH. In this analysis, B was considered as dependent variable and SH, MGS and Qz/Fl were regarded as independent variables as shown below:

$$\mathbf{B} = -5.158 + 0.585\mathbf{SH} - 2.987\mathbf{MGS} \qquad R^2 = 0.91 \qquad (4)$$

$$\mathbf{B} = -3.854 + 0.348\mathbf{SH} + 4.641(\mathbf{Qz/Fl}) \qquad R^2 = 0.93 \qquad (5)$$

4. Conclusions

The results of simple statistical relationships indicate that there are moderate correlations (determination coefficients ranging from 0.70 to 0.87) between the brittleness index with Schmidt hammer hardness, minerals mean size and quartz to feldspar ratio. While the multivariate statistical relationships indicate a significant effect of the minerals mean size and quartz to feldspar ratio on the accuracy of correlation between the brittleness index with Schmidt hammer hardness s (with determination coefficients of 0.91 and 0.93, respectively).

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